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YEAR THIS DEGREE GRANTED ...1973...

THE UNIVERSITY OF ALBERTA

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RAPESEED MEAL AS A PARTIAL OR COMPLETE REPLACEMENT FOR SOYBEAN MEAL IN DIETS OF YOUNG PIGS

by

(C) CHARLES WILLIAM BRIGGS

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

ANIMAL NUTRITION

DEPARTMENT OF ANIMAL SCIENCE

EDMONTON, ALBERTA

FALL, 1973

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Rapeseed Meal as a Partial or Complete Replacement for Soybean Meal in Diets of Young Pigs" submitted by Charles William Briggs, B.Sc., in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

Growth, digestibility and retention studies were designed to compare diets containing rapeseed meal (RSM) supplemented on an isocaloric and isonitrogenous basis for soybean meal (SBM). The growth studies were conducted with weanling pigs for a 7-week period. RSM samples (coded S, A and P) were from the Span cultivar of Brassica campestris, a low erucic acid rapeseed. RSM were substituted for 50 or 100% of the SBM to give total RSM content in the diets of 12.5 and 25 percent. In addition, at the 100% level of substitution, supplemental L-lysine was added to equalize the lysine content with that of the SBM basal diet.

Normal levels of performance for pigs of this age and weight were recorded for diets containing SBM or 50% RSM. Substituting RSM for 100% of the SBM in the diets did not depress performance significantly but gains were numerically lower, particularly for pigs fed two (A and P) of the three RSM samples. Pigs fed diets containing 100% RSM from A and P samples appeared to respond to supplemental lysine but those fed sample S did not. These performance results were not directly related to levels of lysine in the three samples of RSM, as determined by amino acid assays.

There were few significant differences between diets for digestible energy, metabolizable energy, metabolizable energy (nitrogen-corrected), digestible nitrogen and nitrogen retained values. These digestibility and retention data were not sufficiently closely related to gain and feed conversion data to be very valuable in assessing the overall substitution value of the three samples of Span RSM.

ACKNOWLEDGEMENTS

As the author, I wish to thank Dr. L.W. McElroy, Chairman of the Department and Professor of Animal Science, for placing the facilities of the department at my disposal.

For the guidance and advice of Dr. J.P. Bowland, Professor of Animal Nutrition, throughout the course of this study and for his constructive criticisms during the preparation of this manuscript, I am deeply grateful.

Thanks are extended to Dr. R.T. Hardin, Associate Professor of Poultry Genetics, for his help with the statistical analyses. The able assistance of Mr. G. Stephens, Swine Herdsman, The University of Alberta Edmonton Research Station, and his staff during the course of this study is hereby acknowledged.

The patience, cooperation and encouragement afforded me by my parents, throughout the course of this study is gratefully acknowledged.

Financial support for this study, provided by the Rapeseed Association of Canada through a Rapeseed Utilization Assistance Program grant, is hereby acknowledged.

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INTRODUCTION

Rapeseed has become one of the most important cash crops in Western Canada. From a beginning of 1295 hectares (3200 acres) and a production of 1038 metric tons in 1943, rapeseed production has increased to 1,598,580 hectares (3,950,000 acres) in 1970 with a production of 1,875,200 metric tons making Canada one of the world's leading producers and exporters of rapeseed, (Martin 1970). In 1971 and 1972 there were 2,187,770 hectares (5,306,000 acres) and 1,323,340 hectares (3,270,000 acres) respectively seeded to rapeseed. In 1972 the yield was 1,351,550 metric tons which is an average of 1021 kg/hectare (17.5 bushels/acre). The estimated seeded crop for 1973 is 1,274,790 hectares (3,150,000 acres), down 4 percent from the previous year.

Rapeseed meal (RSM) is a high protein by-product of the oil extraction industry. Prior to a change from expeller processing methods, RSM was not used extensively in livestock and poultry diets. The advent of prepress-solvent and solvent extraction methods has been one factor that has changed its potential as a protein supplement in animal feeds.

The common species of rapeseed grown in Western Canada are; *Brassica napus* L. (commonly referred to as Argentine rapeseed) and *Brassica campestris* L. (commonly referred to as Polish rapeseed). Eighty percent of the rapeseed grown in Canada, as reported by the Rapeseed Association of Canada (1972), is *Brassica campestris* a species low in glucosinolates and therefore only slightly goitrogenic. Oxazolidinethione and isothiocyanates, which may arise from the glucosinolates in rapeseed, inhibit thyroid function and may result in adverse effects on animal performance. Rapeseed breeding programs in

Canada are constantly developing new improved cultivars and this is another factor favorably influencing use of the meal.

Due to the growth depressing potential of RSM, swine producers were reluctant to use this meal as a substitute for soybean or other vegetable protein meals. Extensive Canadian research has demonstrated that RSM may be used in pig diets. The development of improved methods of processing and of varieties of rapeseed has led to improvements in the quality of Canadian RSM available to the feed industry. However, it is essential that meal from new varieties or cultivars of rapeseed be evaluated nutritionally before they are accepted as being equal or superior to existing meals.

Feeding and metabolism trials reported in this thesis were conducted with pigs during the summer of 1972 at The University of Alberta, Edmonton Research Station. The studies involved comparison of the Span cultivar of Brassica campestris prepress-solvent RSM from three different Western Canadian processing plants compared with soybean meal (SBM) as protein supplements.

LITERATURE REVIEW

Bell (1955) in a review article reported that rapeseed research dates back to 1872, with the first North American work being carried out in 1944. Increased interest in the use of RSM as a protein supplement has prompted extensive research into many aspects of its production and utilization. A monograph reviewing the literature on the use of RSM as a protein supplement was prepared in Canada in the mid-1960's (Bowland et al., 1965). More recently, in 1972, a report "Canadian Rapeseed Meal in Poultry and Animal Feeding" was prepared under the auspices of the Rapeseed Association of Canada.

A. Methods of processing rapeseed

In Canada, at present there are three methods for processing rapeseed as outlined by Youngs et al. (1972); expeller, prepress solvent, and solvent-extraction. The most widely used procedure in Western Canada is the prepress solvent-extraction method. Clandinin (1967) presented data which indicated that the prepress solvent or solvent method of oil extraction produced RSM that were nutritionally superior to the expeller type meals which were produced in Canada some years ago.

More heat damage may occur in expeller meals than occurs in solvent or prepress solvent meals. Excessive heat, according to Clandinin (1967), results in reduced available lysine content. In earlier work by Riesen et al. (1947) with SBM, they reported that heat alters the protein in such a way that it may be more readily attacked by proteolytic enzymes. Excessive heat results in further change which makes the meal less readily attacked by proteolytic enzymes resulting in decreased liberation following acid hydrolysis of certain amino acids such as lysine, arginine and tryptophan, (Reisen et al., 1947,

and Clandinin et al., 1947). Clandinin (1949) reported that the liberation of the essential amino acids from herring meals by enzymatic hydrolysis was greatly depressed when stack temperatures of 220°F (104°C) were used in comparison with 185°F (85°C). Rutkowski (1970) reported that industrial toaster desolventizers caused a decrease of about one-third in the amount of soluble protein. This decrease varied directly with the severity of the processing conditions.

In the prepress solvent-extraction process, the seed is cleaned to 95% purity or better. The cleaned seed is crushed in roller mills to break the seed structure and allow separation of the oil meal. Crushing is followed by cooking which allows oil-bearing cells to be permeable to oil. The cooking interval is approximately 30 minutes in either stack or horizontal cookers. The crushed, cooked seed progresses to the expeller, or screw press which removes a portion of the oil. Cake from the expellers contains 15 to 20% oil and is rerolled and extracted with hexane. The solvent is stripped from the meal in desolventizers. The solvent-free meal contains around two percent lipid with a moisture content of 10 percent. This is the approximate form of RSM produced in Canada today (Youngs et al., 1972).

B. Characteristic properties of rapeseed meal

RSM contains approximately 36% protein. Robblee and Clandinin (1968) reported that the array of amino acids in RSM tends to be similar to that of SBM and other plant protein products. More specifically, Clandinin et al. (1972) reported that SBM and RSM complement each other in animal diets since SBM contains more lysine than RSM, and RSM contains more methionine than SBM. Clandinin (1967) reported that RSM produced by prepress solvent or solvent-extraction are higher in lysine

and "available lysine" than the expeller type meals. According to Clandinin (1967), the differences in lysine content are mainly attributable to the reduced heat damage occuring in the solvent processing methods. Lysine is normally the first limiting amino acid in practical pig diets (NAS-NRC Nutrient Requirements of Swine, 1968).

The goitrogenic property of feed protein has been of interest since the work of Chesney et al. (1928). The goitrogenic property of RSM was first noticed by Kennedy and Purves in 1941. Astwood et al. (1949) isolated one of the antithyroid compounds and named it L-5-vinyl-thiooxazolidone. The glucosinolates present in rapeseed; pro-goitrin, gluconapin, and glucobrassica napin, can be hydrolysed in the presence of the enzyme myrosinase to 5-vinyl-2-oxazolidinethione, 3-butenyl isothiocyanate, and 4-pentenyl isothiocyanate, respectively.

The heat applied to the seed in the oil extraction process should destroy the hydrolysing enzyme, myrosinase. Belzile and Bell (1966) studied the effects of temperature on myrosinase activity and the level of isothiocyanate and oxazolidinethione in RSM. They found that meal processed at 22°C had less isothiocyanate and oxazolidinethione, and supported better growth in mice than did meals processed at 50°C, confirming the heat deactivation of myrosinase and the deleterious effect of excessive heat on nutritive value.

Rutkowski (1970) observed the difficulties encountered in retrieving a satisfactory meal from the processing plant has led to a new approach in which the plant breeder selects rapeseed varieties with low pro-goitrin content. He believes this approach will most likely provide the best way of obtaining future RSM of the highest feed value. The current study is using a meal from <u>Brassica campestris</u>, cultivar Span, which was developed by a Canadian breeding program. In

this case, a seed containing oil low in erucic acid (C22:1) was the objective, rather than a seed low in glucosinolates.

In considering RSM as an energy source in animal diets, it is important to realize that the metabolizable energy value of RSM for pigs is considerably higher than the equivalent value for chicks (Bowland and Bell, 1972). Experiments at The University of Alberta and The University of Saskatchewan have shown that the average metabolizable energy value of RSM is 2700 kcal per kg feed and the digestible energy value is 2900 kcal per kg feed. A metabolizable energy value for poultry of 1760 kcal per kg of feed was reported by Clandinin et al. (1972). Even with pigs, the levels of digestible energy or metabolizable energy are slightly lower for RSM than for most other vegetable protein sources, so an adjustment to make rations isocaloric is needed when RSM replaces these other protein sources.

In general, the calcium content of RSM is similar to that of other oilseed meals (Bowland et al., 1965). RSM contains about twice as much phosphorus as SBM (Clandinin et al., 1972), and according to unpublished work done at the University of Guelph, the phosphorus in RSM is 70% inorganic compared with only 32% for SBM. RSM is a rich source of selenium, and is high in zinc, magnesium and manganese in relation to SBM (Clandinin et al., 1972). Based on this review, RSM is also relatively high in two vitamins, niacin and choline.

C. Value of rapeseed meal

In a report prepared by Giovannetti and Bell (1971), they noted that important factors that influence the performance of animals fed diets containing RSM were a) the protein content and amino acid balance of the diet, b) the level of substitution of RSM for SBM, and c) the palatability and physiological factors that accompany such substitution.

a. Protein

Drouliscos and Bowland (1969) reported the possibility that in RSM the lignification is so arranged and distributed that the protein in the meal is trapped by the fibrous material and therefore limited in its availability. The high crude fiber content of RSM was associated with increased feed intake in rats (Anderson and Sabry, 1970). In this study by Anderson and Sabry, the protein efficiency ratio (PER) values confirmed results of Drouliscos and Bowland (1968) in which PER of commercial RSM was similar to SBM, but in which growth of rats was significantly depressed on RSM-supplemented diets.

As lysine is usually the first limiting amino acid in swine diets (NAS-NRC Nutrient Requirements of Swine, 1968), beneficial effects have resulted from the use of supplemental lysine in the diet in numerous experiments. For example, Anderson and Bowland(1967) reported that the addition of 0.2 or 0.4% lysine to pig diets based on some of the small cereal grains and containing no RSM, significantly increased the nitrogen retention, gain, and daily feed intake with each increasing level of lysine. Less digestible energy was required per kg of gain with each increase in the lysine level. Bowland (1962) reported that the addition of 0.2% L-lysine to a 13% protein diet improved the rate of gain of growing pigs to a level equal to that obtained with a 16% protein diet. Bowland and Grimson (1968), by increasing the level of L-lysine and methionine in a 14.3% protein starting diet to be equivalent to a 21.5% protein diet, increased the performance of the pigs on the low protein diet to that of those receiving the control diet.

Manns and Bowland (1963b) found a beneficial effect from adding 0.2% L-lysine to the pigs diets in which RSM completely replaced

the SBM in the diet. They also reported increased protein, dry matter, and energy digestibility during growth, gestation and lactation from supplemental lysine in RSM-supplemented diets. Not all experiments have obtained a beneficial response from supplemental lysine added to diets containing high levels of RSM. Manns and Bowland (1963a) reported that the addition of 0.2 percent supplemental lysine to RSM-supplemented diets had no significant influence on rate of gain or feed utilization at any stage of growth in pigs.

b. Level of substitution

The upper level at which RSM may be substituted in swine diets without influencing performance varies with the type of diet and the quality of the meal used. Bayley et al. (1969) reported that prepress solvent-extracted RSM could be fed at a level of 11 percent in corn-SBM-RSM diets supplemented with lysine and methionine without adversely affecting the performance of finishing swine. Conflicting reports, where lower levels of rapeseed meal in finishing diets depressed performance, were considered by Bayley et al. (1969) as being due to the use of expeller meals, or the use of diets with a lower energy content than the corn-based diet used in their experiment.

c. Palatability and physiological factors

The presence of rapeseed in the diet may affect its acceptability and palatability , factors which, according to Schuld (1967), are important to insure adequate feed intake. Clandinin (1961) and Bowland (1957) observed that the sharp bitter taste of RSM, due to the substance sinapin, may result in decreased feed intake or non-acceptance when alternative diets are available.

The evidence is not consistent as to whether RSM in swine diets depresses voluntary feed intake but in general there have been no

significant differences in feed intake associated with RSM in pig diets. For example, Manns (1962) found no adverse effect on feed intake from the addition of RSM.

If non-processed rapeseed is fed, a depression in performance can be expected. This is probably partly associated with acceptability of the diet. Bowland (1971) reported that for growing-finishing pigs fed 5 to 10 % rapeseed in wheat-barley based diets, a reduction of approximately two percent in feed intake could be expected for each one percent addition of rapeseed, regardless of whether adjustments were made in digestible energy and protein. A similar pattern was established for rate of gain.

Feeding of RSM in the diet has been demonstrated to result in thyroid hypertrophy (Hussar and Bowland, 1959;Drouliscos and Bowland, 1968). Drouliscos and Bowland (1968) confirmed the presence of goitrogenic principles in RSM. These goitrogenic principles in RSM have been a major factor limiting its use in swine diets.

D. General recommendations for use of rapeseed meal

Bowland and Bell (1972) compiled general recommendations for the use of RSM. To quote, "RSM of Canadian origin may be used as a portion of all pig rations but when recommended levels are exceeded, then rate of gain, feed efficiency and reproductive performance may be reduced.

For young pigs during the starting period to 25 kg liveweight, four percent to five percent of the ration may be composed of RSM. For market pigs from 25 to 90 kg liveweight, a level of five percent RSM throughout starting, growing and finishing diets provides a substitution level that is satisfactory and easy to formulate. Carcass quality will not be influenced when levels of RSM are fed that are recommended as being satisfactory for growth and feed conversion."

EXPERIMENTAL PROCEDURES

A. Objectives

This experiment was designed to study the effects on feed intake, rate of gain, feed conversion, digestibility of energy and nitrogen and retention of nitrogen when prepress solvent-extracted rapeseed meal (RSM) from a common source of Span rapeseed processed at three separate plants was substituted on a protein and energy equivalent basis for soybean meal (SBM) in diets of young pigs. Span rapeseed is a low erucic acid (LEAR) cultivar of *Brassica campestris*.

B. Methods and procedures

1. General

The growth and metabolism phases of the experiment were conducted from June 9, 1972 to July 28, 1972 at The University of Alberta Research Station, Edmonton, Alberta. Chemical and analytical studies were conducted during and following the growth and metabolism studies.

Feed consumption, daily gain and efficiency of feed utilization were measured during the experimental period. Metabolism trials to determine energy and nitrogen digestibility and nitrogen retention were carried out after the pigs had adjusted to the diets.

2. Experimental design and dietary treatments

The experiment, started on June 9, 1972, consisted of ten dietary treatments with four replicates per treatment. Pigs were fed the ten diets (Table 1) for a seven-week test period. The basal diet consisted of wheat and barley with 2.4% tallow as the energy sources with solvent-extracted SBM as the source of supplemental protein. Three samples of RSM from *Brassica campestris*, Span cultivar, were obtained for comparison with the SBM. Span rapeseed is a low erucic acid (LEAR) variety of rapeseed which has been grown extensively in Western Canada since

Table 1. Formulation and calculated composition (on an air-dry basis) of the soybean meal (SBM) and rapeseed meal (RSM) supplemented[1] diets.

Diet[2]	SBM	RSM-SBM	RSM
Diet numbers	1	2,3,4	5,6,7, 8+,9+,10+
Ingredients %			
Wheat (ground)	50.0	59.0	56.2
Barley (ground)	25.3	12.2	10.7
Tallow, stabilized	2.4	2.6	3.3
SBM (48.5%)	18.0	9.4	0.0
RSM	0.0	12.6	26.0
Salt (iodized)	0.4	0.4	0.4
Ca and P supplement[3]	1.4	1.5	1.1
Ground limestone	1.0	0.8	0.8
Mineral and vitamin[4]	1.5	1.5	1.5
Composition (calculated)			
Protein %	18.2	18.2	18.1
Lysine %	0.91	0.83	0.78
Methionine and cystine %	0.55	0.54	0.54
Digestible enery Kcal/kg	3430.0	3430.0	3410.0
Calcium %	0.74	0.73	0.73
Phosphorus %	0.69	0.70	0.70

[1]Diets 2,5 and 8 contained meal processed at "S" plant, diets 3,6 and 9 contained meal processed at "A" plant, and diets 4, 7 and 10 contained meal processed at "P" plant.

[2]Isocaloric - isonitrogenous substitution of RSM for SBM.

[3]18.5% Ca 20.5 % P

[4]This mineral and vitamin premix provided the following trace minerals:

88 ppm zinc, 76 ppm manganese, 294 ppm iron, 25 ppm copper and 2.8 ppm cobalt. It also provided/100 kg of diet: 440,000 I.U. vitamin A, 55,000 I.U.vitamin D, 1100 I.U. vitamin E, 1100 mg riboflavin, 2.2. g calcium pantothenate, 4.8 g niacin, 5.5. g choline choloride, 165 mg folic acid and 1980 micrograms vitamin B_{12}.

+L-lysine added to equalize calculated lysine levels in diet number 1.

1971. These three samples of Span RSM were from a common source but were processed at three western Canadian plants identified henceforth by code as S, A, and P. Substitution of RSM were made on an isonitrogenous, isocaloric basis for 50% of the SBM (treatments 2,3 and 4), 100% of the SBM (treatments 5, 6 and 7) or 100% of the SBM with L-lysine (treatment 8,9 and 10) added to equalize lysine levels in the RSM diets with that in the SBM diet. All diets contained supplemental minerals and vitamins. Diets were formulated to meet requirements as defined in the National Academy of Science - National Research Council Nutrient Requirements of Swine (1968). The experimental diets were mixed at The University of Alberta Research Station, Edmonton, Alberta. Sufficient feed was mixed at the beginning for the entire test period.

Pigs were weaned at three weeks of age and were kept on a standard diet until allotment. Prior to weaning, pigs were treated in the manner described by Grimson (1969). The pigs were of mixed breeding (Landrace x Lacombe-Yorkshire, Landrace x Hampshire-Yorkshire, Landrace x Yorkshire, Hampshire x Hampshire-Yorkshire or Hampshire x Lacombe-Yorkshire). Each replicate consisted of two gilts and two barrows allotted at an average age of 42 days and average initial weight of 6.9 kg. After allotment, the pigs were self fed with two of the same sex in each of twenty pens measuring 0.62 m by 1.23 m. Pigs were fed in pairs throughout except when individual pigs were allotted for the digestibility studies. Feed consumption and liveweight were determined on a weekly basis. Weight gain and efficiency of feed utilization were calculated from these data. Feed intake during the digestibility studies was included in the overall total for the growth experiment. The barn temperature was maintained at approximately 21°C

throughout the experiment.

3. Digestibility and retention studies

Digestibility and retention studies were conducted to determine the effects of different dietary treatments on energy utilization, nitrogen digestibility and retention.

Thirty pigs (20 barrows and 10 gilts) were selected on the basis of treatment and weight on the day of weighing prior to each week when a digestibility trial was to be run. Selection and allotment of pigs were such that the males from the heaviest to the lightest were used first and the heaviest females from each of the 10 treatments used in the last trials. Eight available metabolism cages were used in the trials conducted. The cages measured 0.38 m by 1.23 m. The room temperature was approximately 21° C. The trials were conducted on the following dates with pigs averaging the weights shown:

June 23 - June 29	9.8 kg
June 30 - July 6	8.5 kg
July 7 - July 13	11.5 kg
July 14 - July 20	16.9 kg

During the trials, the selected pigs were placed in the metabolism cages for a three-day period so they could become accustomed to the cages before fecal and urinary collections were started. On the morning of the fourth day, the pigs were removed from the cages and weighed. The cages were thoroughly cleaned with water and the pigs returned. Total urinary and fecal collections were made for the next three days, after which the pigs were removed from the cages, weighed and returned to their respective pens.

During the digestibility and retention studies, records and col-

lection procedures were as follows:

i. Feed

Pigs were fed the respective diets in three equal quantities at 7:30 am., 12:00 noon and 5:30 pm. during the adjustment and collection periods. In these trials the pigs were fed at a level of 90% of average daily feed consumed by each pig in the week preceeding the metabolism trials. All feed offered was comsumed except where otherwise noted. Gross energy and nitrogen analyses were conducted on the feed (see Methods of chemical analyses).

ii. Feces

Feces were collected each morning during each trail. Each day's collection was placed in a labelled plastic bag and stored at 3°C. At the end of each trial, the total feces collection from each pig was thoroughly mixed, weighed and one sample of approximately 600 g was taken. Following preparation, gross energy and gross nitrogen determinations were done on these samples (see Methods of chemical analysis).

iii. Urine

Urine collections for nitrogen determination were made at the same time as the feces were collected. Volume of urine was measured and aliquots were placed in jars, sealed and stored at 3°C so that a total volume of approximately 1000 ml was collected over the three day collection period.

4. Methods of chemical analyses

i. Gross energy and nitrogen

Gross energy of feed and feces was determined using a Parr Oxygen Bomb Calorimeter[1]. Gross energy analyses were on duplicate 1.0 g sam-

[1]Parr Instrument Co., Moline, Ill., U.S.A.

ples of air-dry feed or feces. Feces samples were first placed in an aluminum tray for air-dry matter determination by placing them in a forced air oven[1] at 60°C for 72 hours, removed and allowed to equilibrate to an air-dry basis for 24 hours. These samples were then ground through a size 8 C and N laboratory mill[2] with a 2 mm mesh screen, placed in labelled plastic bags and sealed.

Gross nitrogen values for feed, feces and urine were determined by the Kjeldahl Method (AOAC). Approximately 2.0 g samples of feed and feces were analyzed for gross nitrogen. Urine nitrogen content was determined on duplicate 5 ml samples of non-dried urine. A commercial Kel-Pak[3] was used a catalyst in the digestion. Ammonia was collected in 50 ml of boric acid and titrated directly with standard sulfuric acid. Where protein values were determined, they were calculated as protein = nitrogen x 6.25.

ii. Amino acid analysis

Following acid hydrolysis, determination of amino acid content of the RSM was on the JEOL JLC-5AH Amino Acid Analyzer. Four samples of each of the three RSM were analyzed to determine a mean value for each amino acid. Trytophan content was not determined due to the necessity of alkaline hydrolysis for assay of this amino acid.

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[1]Despatch Oven Co., Minneapolis, Minn., U.S.A.

[2]Christe and Norris Ltd., Chelmsford, England

[3]Supplies HgO, K_2SO_4, and $CuSO_4$, Matheson Scientific, East Rutherford, N.J., U.S.A.

5. Methods of statistical analysis

All data were analysed using a APL program for analysis of variance developed by the Department of Computing Science (Smillie, 1969). Significant differences between three or more means were tested by application of Duncan's Multiple Range Test (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

A. Amino acid composition of rapeseed meals

Results of amino acid analyses of the three RSM samples are reported in Table 2. A highly significant difference ($P<0.01$) was recorded between the lysine contents of the three meals used in the diets. Rapeseed meal "P" had the highest value and rapeseed meal "A" had the lowest value. Other amino acids which varied between S, A and P samples of RSM were arginine, threonine and NH_3. The results of the amino acid analyses for lysine and methionine and cystine contents of the diets (Table 3) were higher than the values used to calculate the diet compositions, therefore the diets contained more lysine and methionine and cystine than shown in Table 1. The essential amino acid levels in the diets are above the minimum requirements for starting and growing swine (NAS-NRC Nutrient Requirement of Swine, 1968).

B. Growth studies

1. Feed consumption, daily gain and efficiency of feed utilization

The means for each lot for average initial and final weights, average daily feed, average daily gain and efficiency of feed utilization, are listed on Table 4. The statistical analyses of these data and overall means for each factor are also given.

a) Average daily feed

No significant differences in feed consumption were observed between treatments. Manns (1962) and Hussar (1958) observed a depression in feed intake of group-fed pigs receiving RSM. However, Bayley et al. (1969) observed no significant differences in any of the performance parameters studied, which included daily feed consumption, by the add-

Table 2. Amino acid analyses* of RSM and analyses of variance for differences between meals in levels of amino acids (expressed as percentages of protein).

Amino Acid	R S M Samples "S"	"A"	"P"	F-value	Prob.
Alanine	4.42	4.47	4.50	2.34	0.15
Arginine	5.79	5.56	5.76	13.08	0.00**
Aspartic Acid	7.02	6.99	7.17	3.48	0.08
Cystine	2.07	1.98	1.56	1.41	0.29
Glutamic Acid	17.21	17.08	17.32	1.27	0.33
Glycine	5.04	5.04	5.02	0.17	0.85
Histidine	2.79	2.74	2.77	2.61	0.13
Isoleucine	4.11	4.10	4.09	0.20	0.83
Leucine	6.88	6.92	6.96	1.87	0.21
Lysine	6.10	5.64	6.30	78.42	0.00***
Methionine	2.16	2.04	1.97	6.15	0.02*
Phenylalanine	3.95	3.93	4.04	0.36	0.71
Proline	6.69	6.68	6.66	0.21	0.82
Serine	4.29	4.30	4.41	6.69	0.12
Threonine	4.45	4.53	4.60	6.23	0.02*
Tyrosine	2.34	2.39	2.35	0.28	0.76
Valine	5.05	5.04	5.06	0.10	0.91
NH_3	2.35	2.32	2.47	14.76	0.00**
Total %	92.72	91.79	93.04		

* Tryptophan not analyzed due to necessity of alkaline hydrolysis.

Table 3. Composition (analyzed) of diets.

Diet	Supplemental Protein	Gross Energy Kcal/gm	Protein %	Lysine %	Meth & Cystine %
1.	SBM	3820	17.9	0.91	0.55
2.	SBM-RSM (S) 50-50	4110	18.0	0.92	0.63
3.	SBM-RSM (A) 50-50	3980	18.0	0.90	0.62
4.	SBM-RSM (P) 50-50	4030	17.6	0.93	0.59
5.	RSM (S)	4030	17.5	0.87	0.67
6.	RSM (A)	3940	18.9	0.82	0.65
7.	RSM (P)	3950	17.4	0.88	0.60
8.	RSM (S) & lysine	4160	18.1	1.00	0.67
9.	RSM (A) & lysine	3930	19.1	0.95	0.65
10.	RSM (P) & lysine	4090	17.9	1.01	0.60

Table 4. Initial and final average weights, average daily feed, average daily gain, and efficiency of feed utilization for the seven-week experimental period.

Diet	Supplemental Protein	Sex	Average weights Initial	Average weights Final	Average daily Feed	Average daily Gain	Feed per kg gain	Treatment means Daily feed	Treatment means Daily gain	Treatment means Feed per kg gain
			kg	kg	kg	g	kg	kg	g	kg
1	SBM	F	9.0	37.9	1.42	590	2.42			
		M	4.5	24.4	0.97	407	2.38	1.20	499	2.40
2	SBM-RSM (S) 50:50	F	8.0	33.6	1.17	522	2.24			
		M	5.3	27.6	1.07	455	2.35	1.12	489	2.30
3	SBM-RSM (A) 50:50	F	7.0	30.9	1.18	489	2.42			
		M	5.9	29.0	1.08	471	2.28	1.13	480	2.35
4	SBM-RSM (P) 50:50	F	7.2	34.2	1.28	549	2.33			
		M	6.2	28.7	0.95	460	2.07	1.11	505	2.20
5	RSM (S)	F	7.4	27.8	1.04	415	2.50			
		M	5.4	21.4	1.06	429	2.49	1.06	422	2.50
6	RSM (A)	F	7.9	27.9	1.02	408	2.50			
		M	5.6	17.9	0.90	252	3.59	1.04	330	3.04
7	RSM (P)	F	8.1	28.6	1.08	419	2.57			
		M	5.5	18.5	0.73	265	2.74	0.91	342	2.66
8	RSM (S) & lysine	F	8.6	31.6	1.21	468	2.58			
		M	4.6	22.1	0.88	356	2.47	1.04	412	2.53
9	RSM (A) & lysine	F	8.0	31.3	0.98	475	2.06			
		M	5.6	24.1	0.88	378	2.34	0.94	427	2.20
10	RSM (P) & lysine	F	7.0	29.0	1.19	447	2.66			
		M	6.2	24.7	0.86	378	2.28	1.02	413	2.47
Overall Means		F	7.8	31.3	1.15	480	2.43			
		M	5.5	23.8	0.94	380	2.50			
Grand Mean			6.6	27.6	1.05	430	2.46			
Probability	Sex interaction				0.00	0.08	0.60			
	Treatment interaction				0.30	0.79	0.28			

ition of RSM at a level of 11% in pig diets.

A significant difference in daily feed consumption was observed between sexes probably mainly due to the higher starting weights of the females. Female average starting weights were 7.8 kg while male average starting weights were 5.5 kg. Male pigs fed RSM consistently consumed slightly less feed during the test period. Anderson and Bowland (1967) reported daily feed intake was not influenced by the sex of the pig.

b) Average daily gain

No significant differences were observed between treatment or sex in average daily gain. Manns and Bowland (1963b) reported, in studies where RSM replaced 100% of the SBM, that rate of gain was reduced approximately 20 percent. At the 50% level of substitution, they observed variable, but inferior results for pigs receiving RSM. In general, daily gain is not depressed if 5% or less RSM is fed in the total diet (Bowland and Bell, 1972). In the current study, there was approximately 12% RSM in diets when 50% of the SBM was replaced by RSM. At this level of substitution there was no suggestion of a deleterious effect on daily gains. Although not significantly different, the diets containing 100% RSM in substitution for SBM (25% RSM in the total diet) resulted in gains which were numerically below those of the pigs receiving only SBM. The results suggest that meal from Span rapeseed may be fed at levels much above the current recommendation of 5% of the total diet with no depressive effects on performance.

c) Efficiency of feed utilization

Efficiency of feed utilization, measured as kg of feed per kg of

gain, was not significantly different between treatments or between sexes. According to Bowland et al. (1965), any growth depression occurring when RSM is fed is usually closely related to reduced feed intake and efficiency of feed utilization is not adversely influenced by substitution of RSM for SBM in the ration. This observation assumes that isocaloric diets are fed.

There were no significant differences ($P<0.05$) between treatments in feed intake, rate of gain of efficiency of feed conversion in the current experiment. However, treatments 6 and 7, on a numerical basis, gained more slowly and treatment 7 had a poorer feed conversion than any other treatment. Although these differences were not significant at the usually accepted level of probability, they suggest that lysine was limiting in the two meals (A and P) compared with S, as the addition of lysine in treatments 9 and 10 (A and P meals) raised performance to a level equivalent to that of treatment 8 (S meal with lysine). Amino acid assays indicated that A had a significantly lower level of lysine than S but that P was higher than S. Therefore, amino acid assays do not indicate that lysine levels were necessarily associated with gain, but do not rule out differential availability of lysine. The reason for lack of statistical significance without very large numerical differences is probably related to rather large differences between the sexes in performance, thus introducing a large within treatment error which could not be entirely removed.

2. <u>Digestibility and retention studies</u>

a) <u>Digestible energy</u>

Digestible energy (DE) in the diets measured as DE in feed expressed as a percentage of gross energy in the feed (Table 5), gave coeffic-

Table 5. Digestible energy (DE) coefficients in diets (DE in feed/ gross energy in feed, expressed as a percentage).

Diet	Supplemental Protein	DE Mean	DE Mean Female	DE Mean Male			
1	SBM	87.6	89.9	85.4	Prob:	T	0.96
2	SBM-RSM(S) 50-50	86.7	89.2	84.1		S	0.53
3	SBM-RSM(A) 50-50	88.0	88.5	87.5			
4	SBM-RSM(P) 50-50	88.3	89.0	87.6			
5	RSM(S)	85.2	86.5	84.0			
6	RSM(A)	86.5	84.7	88.3			
7	RSM(P)	86.2	81.5	91.0			
8	RSM(S) & lysine	89.5	88.0	91.0			
9	RSM(A) & lysine	89.0	92.5	85.5			
10	RSM(P) & lysine	86.3	88.6	83.9			
Overall Mean		87.3	87.8	86.8			

ients which were not significantly different between treatments or between sexes. Bowland (1971) reported sex differences in several criteria, one of them being that the barrows had higher coefficients for DE than gilts. Skitsko and Bowland (1970) observed no influence of sex on DE. Saben et al. (1971) obtained no differences in DE for diets fed to pigs weighing 16, 33 or 65 kg liveweight. Energy digestibilities (Table 5) agree with results of Anderson and Bowland (1967), where lysine levels had no effect on the apparent digestibility of energy. They also found that the narrowest calorie:lysine ratio in their study gave the maximum gains, indicating the ratio should be at least 3500 kcal DE per kg per unit percentage lysine. The diets in the current study had ratios of 3500 to 4160 kcal DE per kg per unit percentage lysine. The narrowest ratio did not give the maximum gains in this study. Anderson and Bowland (1967) also reported feed consumption was increased at the highest levels of lysine. Results of feed consumption for the current study are not in accordance with that research.

DE values, measured kcal DE per kg of feed (Table 6), were not significantly different between treatments or between sexes, although there were some apparent differences. Average DE values for all treatments were 3500 kcal per kg feed. Probabilities and results of Duncan's Multiple Range Test are also shown on Table 6. When DE values were considered for the males only, there were significant differences between treatments ($P<.05$). Diet number 8 containing RSM S replacing 100% of the SBM and supplemented with L-lysine had a DE value which was significantly different from and superior to all other diets ($P<0.01$). Diet number 8 had the highest gross feed energy (kcal/g) (Table 3) of all of the rations and this undoubtedly was partially responsible for

Table 6. Digestible energy (DE) (kcal/kg feed) content of diets.

Diet	Supplemental Protein	DE Mean	DE Mean Female	DE Male			
1	SBM	3352	3438	3265[c]	Prob:	T	0.15
2	SBM-RSM (S) 50:50	3565	3669	3460[c]		S	0.52
3	SBM-RSM (A) 50:50	3508	3528	3487[c]	Male*		0.04
4	SBM-RSM (P) 50:50	3560	3588	3531[b]			
5	RSM (S)	3436	3488	3383[c]			
6	RSM (A)	3411	3341	3481[c]			
7	RSM (P)	3329	3146	3512[b]			
8	RSM (S) & lysine	3836	3773	3899[a]			
9	RSM (A) & lysine	3496	3635	3357[c]			
10	RSM (P) & lysine	3528	3624	3433[c]			
Overall Mean		3502	3523	3481			

* Male treatment interaction tested separately.

the high DE values for this diet as DE coefficients did not vary significantly between diets (Table 5). Manns and Bowland (1963a) found there was a beneficial effect from adding 0.2% supplemental L-lysine to pig rations containing a high level of RSM. At the 5% level of significance, the diets using RSM P without supplemental lysine (treatments 4 and 7) had DE values which were higher than other diets except treatment 8. In this case, lysine was of no benefit so there is no clear picture emerging from DE data.

b) Metabolizable energy

Metabolizable energy (ME) coefficients of the diets measured as ME in the feed expressed as a percentage of gross energy in the feed are presented on Table 7. ME-nitrogen corrected (ME_n) coefficients expressed as a percentage are presented on Table 8. These coefficients followed a pattern similar to DE coefficients and did not differ significantly between treatments or between sexes. Bowland (1971) reported sex differences where barrows had higher ME and ME_n coefficients than gilts. However, Saben et al. (1971) obtained no sex differences in ME of ME_n for diets containing RSM fed to pigs weighing 16, 33 or 65 kg liveweight.

ME values measured as kcal ME per kg feed (Table 9) were not significantly different ($P<0.05$) between treatments or between sexes. When ME values were considered for barrows only, there were significant differences between treatments ($P<0.10$). Probabilities and results of Duncan's Multiple Range Test are shown on Table 6. The results at the 10% level of significance for ME are equivalent to those at the 5% level for DE. Bowland (1971) reported a correlation of DE with ME of $r=0.980$ for pigs fed RSM diets.

Table 7. Metabolizable energy (ME) coefficients in diets (ME in feed/ gross energy in feed, expressed as a percentage).

Diet	Supplemental Protein	ME Mean	ME Mean Female	ME Mean Male			
1	SBM	85.7	87.9	83.6	Prob:	T	0.97
2	SBM-RSM (S) 50:50	85.1	88.0	82.2		S	0.63
3	SBM-RSM (A) 50:50	86.4	87.0	85.8			
4	SBM-RSM (P) 50:50	87.0	87.6	86.4			
5	RSM (S)	83.7	84.7	82.7			
6	RSM (A)	85.1	83.0	87.2			
7	RSM (P)	84.4	79.5	89.4			
8	RSM (S) & lysine	88.1	86.0	90.2			
9	RSM (A) & lysine	87.6	91.6	83.6			
10	RSM (P) & lysine	85.0	87.1	82.9			
Overall Mean		85.8	86.2	85.4			

Table 8. Metabolizable energy (nitrogen corrected) (ME_n) as a percentage of the diets.

Diet	Supplemental Protein	ME_n Mean	ME_n Mean Female	ME_n Mean Male			
1	SBM	83.9	86.0	81.8	Prob:	T	0.97
2	SBM-RSM (S) 50:50	83.6	86.8	80.4		S	0.73
3	SBM-RSM (A) 50:50	84.8	85.4	84.2			
4	SBM-RSM (P) 50:50	85.8	86.3	85.2			
5	RSM (S)	82.2	82.9	81.4			
6	RSM (A)	83.8	81.4	86.2			
7	RSM (P)	82.7	77.5	87.9			
8	RSM (S) & lysine	86.8	84.1	89.4			
9	RSM (A) & lysine	86.2	90.7	81.7			
10	RSM (P) & lysine	83.8	85.7	81.9			
Overall Mean		84.3	84.7	84.00			

The overall results for DE, ME and ME_n coefficients and for those measures expressed as kcal per kg diet suggest no consistent advantage from L-lysine supplementation of diets containing high levels of RSM.

c) Digestible nitrogen

Digestible nitrogen (DN) coefficients for the ten diets are given in Table 10. There were no significant differences exhibited between treatments or between sexes. By observation, RSM S had the lowest values at the 50 and 100% levels of substitution (diets 2 and 5) without supplemental lysine. This apparent difference is more evident in the barrows than the gilts ($P<0.25$) with the barrows having a lower overall mean value. According to Bowland (1971, barrows had higher coefficients for DN than gilts, but Saben et al. (1971) and Skitsko and Bowland (1970) observed no influence of sex on DN. DN values of the current study agree with Bowland (1971), who observed that as the level of protein increases in the diet, it normally results in an increase in apparent DN because of the decreased influence of the metabolic fecal nitrogen component.

In the current study, the mean DN coefficients for the gilts were slightly higher ($P<0.25$) than for the barrows. Bowland (1971) reported higher values for barrows than gilts, but these differences were associated with higher feed intake and hence higher protein intake per unit of liveweight of the barrows compared with the gilts. Since the barrows were lighter and younger in the current study, the sex differences are confounded with liveweight during the digestion trials.
DN values measured as g N per kg feed (Table 11) indicated that a difference between treatments ($P<0.10$) existed on an overall basis. DN values on this basis did not differ significantly between sexes.

Table 9. Metabolizable energy (ME) (kcal/kg feed) content of diets.

Diet	Supplemental Protein	M E Mean	Mean Female	Mean Male			
1	SBM	3279	3363	3195[c]	Prob:	T	0.19
2	SBM-RSM (S) 50:50	3502	3619	3383[c]		S	0.63
3	SBM-RSM (A) 50:50	3442	3465	3420[c]	Male*		0.07
4	SBM-RSM (P) 50:50	3508	3532	3483[b]			
5	RSM (S)	3373	3414	3332[c]			
6	RSM (A)	3356	3274	3438[c]			
7	RSM (P)	3261	3069	3453[b]			
8	RSM (S) & lysine	3777	3688	3866[a]			
9	RSM (A) & lysine	3440	3598	3283[c]			
10	RSM (P) & lysine	3477	3564	3390[c]			
Overall Mean		3442	3459	3424			

* Male treatment interaction tested separately.

Table 10. Digestible nitrogen (DN) in diets expressed as a percentage of nitrogen intake.

Diet	Supplemental Protein	D N Mean	Mean Female	Mean Male			
1	SBM	87.2	90.4	84.1	Prob:	T	0.68
2	SBM-RSM (S) 50:50	83.9	87.0	80.8		S	0.22
3	SBM-RSM (A) 50:50	86.6	87.2	85.9			
4	SBM-RSM (P) 50:50	88.4	89.9	86.8			
5	RSM (S)	83.7	85.2	82.2			
6	RSM (A)	88.8	88.4	89.2			
7	RSM (P)	88.9	86.9	91.0			
8	RSM (S) & lysine	89.2	85.7	92.7			
9	RSM (A) & lysine	88.9	93.6	84.2			
10	RSM (P) & lysine	85.8	87.4	84.2			
Overall Mean		87.1	88.2	86.1			

When gilts and barrows were analyzed separately, a higher significance ($P<0.05$) existed between treatments for the barrows. Probabilities and results of Duncan's Multiple Range Test are also given on Table 11. For barrows, DN coefficients were increased in the A and P diets at the 100% level of substitution when lysine was added. This result is similar to that obtained by Manns and Bowland (1963b) when lysine was added to the highest level of RSM-supplemented diets. The S diet at the 100% level of substitution and supplemented with lysine had a lower protein content than the A or P diet which could account for the lower absolute DN value. The response in DN when lysine was added to the A and P RSM diets corresponds to the increase in daily gain of pigs on these same treatments (9 and 10) compared with treatments 6 and 7.

On the basis of digestion coefficients, there were no significant differences between treatments in DE or DN which averaged 86.8 and 86.1%, respectively. However, these were significantly different in DE expressed as kcal per kg diet and in DN expressed as g N per kg diet but these differences are difficult to explain. ME and ME_n followed similar patterns to DE and averaged 3442 kcal per kg diet and 84.0%, respectively.

d) Nitrogen retained

Nitrogen retained (NR) expressed as a percentage of N intake (Table 12) and NR expressed as a percentage of DN (Table 13) exhibited coefficients which did not differ significantly between treatments or between sexes. Skitsko and Bowland (1970) reported that NR expressed as a percentage of total N intake was not significantly influenced by diet. However, a lower percentage of dietary N as a percentage of digested N was retained on a high energy diet than on a low energy

Table 11. Digestible nitrogen (DN) expressed as g N/kg feed.

Diet	Supplemental Protein	DN/kg feed Mean	Mean Female	Mean Male			
1.	SBM	24.9	25.8	24.0[c]	Prob:	T	0.08
2	SBM-RSM (S) 50:50	24.2	25.1	23.3[c]		S	0.21
3	SBM-RSM (A) 50:50	24.9	25.1	24.7[c]	Male*		0.02
4	SBM-RSM (P) 50:50	24.9	25.4	24.5[c]			
5	RSM (S)	23.4	23.8	23.0[c]			
6	RSM (A)	26.9	26.8	27.0[a]			
7	RSM (P)	24.8	24.2	25.4[b]			
8	RSM (S) & lysine	25.9	24.9	26.9[ab]			
9	RSM (A) & lysine	27.2	28.7	25.8[b]			
10	RSM (P) & lysine	24.5	25.0	24.1[c]			
Overall Mean		25.2	25.5	24.9			

* Male treatment interaction tested separately.

Table 12. Nitrogen retained (NR) as a percentage of nitrogen intake.

Diet	Supplemental Protein	NR / Nitrogen intake Mean	Mean Female	Mean Male			
1.	SBM	50.5	52.5	48.5	Prob:	T	0.94
2	SBM-RSM (S) 50:50	52,4	62.5	42.3		S	0.73
3	SBM-RSM (A) 50:50	53.8	55.8	51.8			
4	SBM-RSM (P) 50:50	62.0	61.6	62.5			
5	RSM (S)	51.5	47.1	56.0			
6	RSM (A)	63.0	56.6	69.3			
7	RSM (P)	53.6	46.8	60.4			
8	RSM (S) & lysine	60.2	44.0	76.4			
9	RSM (A) & lysine	62.6	76.0	49.2			
10	RSM (P) & lysine	59.8	51.0	62.7			
Overall Mean		56.9	55.9	57.9			

diet. They felt this difference may be associated with the different absolute levels of protein in the experimental diets. These workers also reported that sex had no effect on NR expressed as a percentage of N intake.

NR expressed as g N retained per kg feed are given in Table 14. There were no significant differences between treatments or between sexes in this criterion. Bowland (1971), using unprocessed rapeseed as an energy and protein source in diets for growing pigs, also found no significant differences among dietary treatments in NR coefficients of NR as g N per kg feed.

Table 13. Nitrogen retained (NR) as a percentage of nitrogen digested (DN).

Diet	Supplemental Protein	NR/DN Mean	Mean Female	Mean Male			
1.	SBM	61.3	58.1	64.5	Prob:	T	0.96
2.	SBM-RSM (S) 50:50	62.2	71.8	52.6		S	0.42
3.	SBM-RSM (A) 50:50	62.1	64.0	60.3			
4.	SBM-RSM (P) 50:50	70.2	68.4	72.0			
5.	RSM (S)	61.7	55.3	68.2			
6.	RSM (A)	70.4	64.0	76.8			
7.	RSM (P)	59.9	53.9	65.8			
8.	RSM (S) & lysine	66.7	51.3	82.2			
9.	RSM (A) & lysine	69.8	81.1	58.4			
10.	RSM (P) & lysine	69.8	65.1	74.4			
Overall Mean		65.4	63.3	67.5			

Table 14. Nitrogen retained (NR) expressed as g N/kg feed.

Diet	Supplemental Protein	N R Mean	Mean Female	Mean Male			
1	SBM	15.2	15.0	15.4	Prob:	T	0.85
2	SBM-RSM(S) 50:50	15.1	18.0	12.2		S	0.68
3	SBM-RSM (A) 50:50	15.5	16.1	14.9			
4	SBM-RSM (P) 50:50	17.5	17.4	17.6			
5	RSM (S)	14.4	13.2	15.7			
6	RSM (A)	19.1	17.1	21.0			
7	RSM (P)	15.0	13.1	16.8			
8	RSM (S) & lysine	17.5	12.8	22.2			
9	RSM (A) & lysine	19.2	23.3	15.0			
10	RSM (P) & lysine	17.1	16.3	17.9			
Overall Mean		16.5	16.2	16.9			

SUMMARY AND CONCLUSIONS

In reviewing the performance data of this experiment, the pigs on the basal diet had average daily feed intake of 1.20 kg, an average daily gain of 499 g and a feed per gain ratio of 2.40 kg for a 7-week experimental period. This level of performance is normal for pigs of this age and weight. Pigs on the RSM-containing diets at the 50% level of substitution had an average daily feed intake of 1.16 kg, average daily gain of 490 g and a feed per gain ratio of 2.28 kg. Pigs on the RSM-containing diets at the 100% level of substitution had an average daily feed intake of 1.00 kg, average daily gain of 365 g and a feed per gain ratio of 2.73 kg. At the 100% level of substitution plus supplemental L-lysine, there was an average daily feed of 1.00 kg, average daily gain of 417 g and a feed per gain ratio of 2.40 kg. Substituting RSM from Span rapeseed for 50% of the SBM in the diets had no influence on performance. Substituting RSM for 100% of the SBM in the diets did not depress performance significantly but gains were numerically lower, particularly for pigs fed two (A andP) of the three samples of RSM.

The addition of supplemental lysine to the RSM-containing diets raised the level of lysine in the diets well above the minimum requirements and therefore narrowed the calorie-lysine ratio to nearer the suggested optimum of 3500 kcal DE per kg per unit percentage lysine. The range of the ratio in this study was 3500 to 4160 kcal DE per kg per unit percentage lysine. Pigs fed diets containing 100% RSM from A and P samples appeared to respond to supplemental lysine while those fed samples S did not. These performance results were not directly related to levels to lysine in the three samples of RSM as determined by

amino acid assays.

Although there were a few significant differences between diets for DE, ME, ME_n, DN and NR values, particularly for barrows, these digestibility and retention data were not sufficiently closely related to gain and feed conversion data to be too valuable in assessing the overall substitution value of the three samples of Span meal.

Many of the differences which were reported as being associated with sex are confounded in this experiment by the existence of lighter and younger barrows than gilts. The gilts had an overall higher average daily feed consumption, average daily gain and lower feed consumed per kg gain. In the digestibility and retention studies the advantage of the male pig over the female pig was again confounded by the age and weight difference.

The overall results suggest that RSM from Span cultivar of Brassica campestris can be completely substituted for SBM giving levels of 25% RSM in the total diet of starting pigs without, in most cases, resulting in no significant depression in performance. These levels are far in excess of the present recommendation that not more than 5% RSM should be used in such diets. A 50% level of substitution of RSM for SBM, from the results of this study, would appear to be a safe level of substitution for the Span cultivar. There was evidence of some variability among the three samples S, A, and P of Span meal processed at different plants by the prepress solvent process in all cases, and these differences appeared to be associated with lysine availability.

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